problems and other management practices that create environments unfavorable to pests.

Energy

Increased food productivity is related to increased use of energy. In the developing world the major source of power for agriculture continues to be human labor and animal power. In developed nations, power is supplied by agricultural machinery that is fueled largely by petroleum. Much energy is also consumed in irrigation, transportation, food processing, and the manufacture of agricultural chemicals and fertilizers. One effect of such modernization is that fewer people can produce greater quantities of food. A point of diminishing returns can be reached, however, where adding more energy to agricultural processes becomes an inefficient use of that energy. In mechanized agricultural systems, as much as 10 times more energy is used to produce food than is returned to society as food for consumption. In many developing nations, however, energy invested in agricultural production generally returns up to 20 times more in food products than is expended during production. Nevertheless, developing nations, in order to most fully utilize their food potential, will have to apply much more energy than previously to agriculture, especially in the areas of improved tillage, more fertilizer, and timely harvesting.

INCREASING FOOD PRODUCTION

If standards of living in less developed countries (LDCs) are to be raised beyond subsistence level, increases in food production must exceed population growth in those countries.

Land Reform

In many parts of the world--particularly in Latin America--the distribution of land is grossly inequitable, with small minorities of wealthy landowners controlling major portions of the best agricultural land. Often these landowners focus on the production of cash crops for the export market. Poor subsistence farmers are forced to farm small plots of marginally productive land to provide for their own needs. The need for reform of land-tenure patterns is apparent in these situations, but land reform is a political issue; often those with the power to direct such land-reform policies are the very people who stand to lose land. Consequently, land-tenure patterns tend to change slowly.

Governments of several nations--notably China, Cuba, Egypt, Iran, Kenya, Mexico, and Taiwan--have experienced some success with land-reform programs. Generally, these programs provide poor farmers with secure access to agricultural land through such policies as rent control for tenant farmers or direct expropriation and redistribution of large land holdings. Increased employment opportunities in the rural sector of the economy, increased land productivity, and a rise in the standard of living have resulted but are dependent on the small farmers' access to credit, education, and other government support services coupled with land reform itself.

Use of Machinery

In the more affluent nations, large-scale mechanization of agriculture has increased the amount of food that can be produced by each worker in agriculture and thus has reduced the need for labor and the number of on-the-farm jobs. In many LDCs, however, where labor is plentiful and incomes often desperately low, governments now seek "appropriate" technologies that are scaled to the small size of typical farms and that are designed to improve labor efficiency but not to replace it.

Where modern agricultural technologies--artificial fertilizers and pesticides, complex sophisticated machinery, large and expensive irrigation projects--have been applied in countries with "undeveloped" agricultures, the results often have been unsatisfactory. Large dams may prove to have negative environmental impacts. Heavy machinery breaks down, needs expensive fuel, and affects fragile soils. New seeds prove to be unsuited to the climate, soil, or growing conditions of the new countries where they are planted.

Trying to impose advanced techniques in areas that practice traditional agriculture may often do more harm than good. Recent attempts to improve traditional technologies seek to provide small-scale devices that are inexpensive, easy to produce, and meet the needs of a specific region. Stoves, for example, may not seem vital to a village's well-being, but traditional ways of cooking, such as using open fires, are inefficient, consume firewood out of proportion to the cooking heat they provide, and are the principal cause of deforestation in many undeveloped regions. Clay, stone, or scrap-iron stoves have been designed that are inexpensive to make and use less than half the fuel of open fires. Solar stoves capture the Sun's heat to provide fire for cooking. Solar vegetable dryers can preserve a season's crop of fruits and vegetables. Improvements on the traditional granary storage baskets, the

problems and other management practices that create environments unfavorable to pests.

Energy

Increased food productivity is related to increased use of energy. In the developing world the major source of power for agriculture continues to be human labor and animal power. In developed nations, power is supplied by agricultural machinery that is fueled largely by petroleum. Much energy is also consumed in irrigation, transportation, food processing, and the manufacture of agricultural chemicals and fertilizers. One effect of such modernization is that fewer people can produce greater quantities of food. A point of diminishing returns can be reached, however, where adding more energy to agricultural processes becomes an inefficient use of that energy. In mechanized agricultural systems, as much as 10 times more energy is used to produce food than is returned to society as food for consumption. In many developing nations, however, energy invested in agricultural production generally returns up to 20 times more in food products than is expended during production. Nevertheless, developing nations, in order to most fully utilize their food potential, will have to apply much more energy than previously to agriculture, especially in the areas of improved tillage, more fertilizer, and timely harvesting.

INCREASING FOOD PRODUCTION

If standards of living in less developed countries (LDCs) are to be raised beyond subsistence level, increases in food production must exceed population growth in those countries.

Land Reform

In many parts of the world--particularly in Latin America--the distribution of land is grossly inequitable, with small minorities of wealthy landowners controlling major portions of the best agricultural land. Often these landowners focus on the production of cash crops for the export market. Poor subsistence farmers are forced to farm small plots of marginally productive land to provide for their own needs. The need for reform of land-tenure patterns is apparent in these situations, but land reform is a political issue; often those with the power to direct such land-reform policies are the very people who stand to lose land. Consequently, land-tenure patterns tend to change slowly.

Governments of several nations--notably China, Cuba, Egypt, Iran, Kenya, Mexico, and Taiwan--have experienced some success with land-reform programs. Generally, these programs provide poor farmers with secure access to agricultural land through such policies as rent control for tenant farmers or direct expropriation and redistribution of large land holdings. Increased employment opportunities in the rural sector of the economy, increased land productivity, and a rise in the standard of living have resulted but are dependent on the small farmers' access to credit, education, and other government support services coupled with land reform itself.

Use of Machinery

In the more affluent nations, large-scale mechanization of agriculture has increased the amount of food that can be produced by each worker in agriculture and thus has reduced the need for labor and the number of on-the-farm jobs. In many LDCs, however, where labor is plentiful and at times often desperately low, governments now seek "appropriate" technologies that are scaled to the small size of typical farms and that are designed to improve labor efficiency but not to replace it.

Where modern agricultural technologies--artificial fertilizers and pesticides, complex sophisticated machinery, large and expensive irrigation projects--have been applied in countries with "undeveloped" agricultures, the results often have been unsatisfactory. Large dams may prove to have negative environmental impacts. Heavy machinery breaks down, needs expensive fuel, and affects fragile soils. New seeds prove to be unsuited to the climate, soil, or growing conditions of the new countries where they are planted.

Trying to impose advanced techniques in areas that practice traditional agriculture may often do more harm than good. Recent attempts to improve traditional technologies seek to provide small-scale devices that are inexpensive, easy to produce, and meet the needs of a specific region. Stoves, for example, may not seem vital to a village's well-being, but traditional ways of cooking, such as using open fires, are inefficient, consume firewood out of proportion to the cooking heat they provide, and are the principal cause of deforestation in many undeveloped regions. Clay, stone, or scrap-iron stoves have been designed that are inexpensive to make and use less than half the fuel of open fires. Solar stoves capture the Sun's heat to provide fire for cooking. Solar vegetable dryers can preserve a season's crop of fruits and vegetables. Improvements on the traditional granary storage bins are the

use of cement rather than tin to store water--these and many other devices could lighten the burden of work in villages and preserve resources as well.

Improving the productivity of farm animals is another neglected area. Using specially designed scoops, a team of oxen can dig out a pond to catch and hold underground rainwater. Although most animal-pulled plows require two draft animals, a special plow has been designed for farmers who own only one animal.

Other areas of small but important technological advance include improving animal nutrition and soil fertility by growing nitrogenous food and fodder, such as cowpeas; using small gasoline-powered plows and other machinery that can be managed and operated by one person; increasing the use of terraces in hilly regions to lower soil erosion; and building raised seedbeds to increase evaporation from waterlogged soils.

Genetic Technology

PLANT BREEDING is modification of a plant's genetic makeup in a purposeful way. The general goal of plant breeding is to assemble into single varieties the best possible combination of genes that control desirable traits. The traits of importance include yield, local environmental adaptation, uniformity, quality, disease or insect resistance, and early maturity. Numerous plant-breeding methodologies can be used worldwide, but actual testing of experimental varieties must be done in the regions in which they are planned for use in order to ensure suitability. Because the raw material for plant breeding is genetic diversity, gene banks--which have collections of seeds of wild relatives and unimproved and improved varieties of crops--have been organized to preserve the genetic resources of major food crops for future use by plant breeders (see GENE BANK).

Efforts of agricultural research in the 1960s to find ways for farmers in developing countries to produce far more food on the same amount of land led to early successes popularly called the green revolution, initiated by a plant scientist, Dr. Norman BORLAUG. Research centers in Asia, Africa, and Latin America conduct applied research on subsistence food crops and livestock problems of regional importance. The best-known centers are the International Rice Research Institute in the Philippines--which developed hardy, short-stemmed rice--and the International Center for the Improvement of Corn and Wheat in Mexico, which developed high-protein corn and wheat adaptable to subtropical regions. Nearly 50 percent of the world's wheat land was sown in the new wheats, and more than a quarter of all rice land was sown in the new rice by the mid-1970s.

Enthusiasm for the early success of the international research centers has been tempered by a growing realization that agricultural change is much more complex than had originally been anticipated, and that high production levels with the new seeds require a costly package that includes, for instance, chemical fertilizers and pesticides that are often unavailable to small farmers.

There are, however, many opportunities for countries to develop native plants into important food crops. Ethiopia, plagued by drought and famine in the 1980s, provides a case in point. The Ethiopians grow a grain called t'ef, which, it is believed, has barely developed from its original wild form. Unlike other staple grains, t'ef needs little rain and grows well in high, cold regions. Its straw makes excellent fodder, and its tiny grains are highly nutritious for humans. Breeding the right varieties of t'ef--that is, working with those seeds which presently grow on marginal land under arid, cold conditions-- could result in a grain that might provide basic food needs for Ethiopia as well as for other mountainous African countries.

Ethiopia is one of the rare places in the world where many plant species that now grow in a host of different varieties around the world can still be found in their primitive, uncultivated forms. Some of them offer great potential: there are many hundreds of wild pea varieties, for example. Oil plants such as the castor bean have yet to receive attention from researchers; coffee, whose wild ancestors still flourish in Ethiopia, might become an important export crop for the country, which at present has none.

These, and many other plants that offer great genetic diversity, are collected and sent to gene banks, but their existence on their native soil is threatened by the introduction of new, high-yielding foreign plants developed by plant breeders outside Ethiopia.

Agricultural Education

New information and technology that can help farmers increase their production must be communicated effectively if it is to achieve its purpose. Physical constraints, such as a poor road system, can handicap the spread of information, but various cultural constraints--including verbal or scientific illiteracy among farmers or the

use of cement rather than tin to store water--these and many other devices could lighten the burden of work in villages and preserve resources as well.

Improving the productivity of farm animals is another neglected area. Using specially designed scoops, a team of oxen can dig out a pond to catch and hold underground rainwater. Although most animal-pulled plows require two draft animals, a special plow has been designed for farmers who own only one animal.

Other areas of small but important technological advance include improving animal nutrition and soil fertility by growing nitrogenous food and fodder, such as cowpeas; using small gasoline-powered plows and other machinery that can be managed and operated by one person; increasing the use of terraces in hilly regions to lower soil erosion; and building raised seedbeds to increase evaporation from waterlogged soils.

Genetic Technology

PLANT BREEDING is modification of a plant's genetic makeup in a purposeful way. The general goal of plant breeding is to assemble into single varieties the best possible combination of genes that control desirable traits. The traits of importance include yield, local environmental adaptation, uniformity, quality, disease or insect resistance, and early maturity. Numerous plant-breeding methodologies can be used worldwide, but actual testing of experimental varieties must be done in the regions in which they are planned for use in order to ensure suitability. Because the raw material for plant breeding is genetic diversity, gene banks--which have collections of seeds of wild relatives and unimproved and improved varieties of crops--have been organized to preserve the genetic resources of major food crops for future use by plant breeders (see GENE BANK).

Efforts of agricultural research in the 1960s to find ways for farmers in developing countries to produce far more food on the same amount of land led to early successes popularly called the green revolution, initiated by a plant scientist, Dr. Norman BORLAUG. Research centers in Asia, Africa, and Latin America conduct applied research on subsistence food crops and livestock problems of regional importance. The best-known centers are the International Rice Research Institute in the Philippines--which developed hardy, short-stemmed rice--and the International Center for the Improvement of Corn and Wheat in Mexico, which developed high-protein corn and wheat adaptable to subtropical regions. Nearly 50 percent of the world's wheat land was sown in the new wheats, and more than a quarter of all rice land was sown in the new rice by the mid-1970s.

Enthusiasm for the early success of the international research centers has been tempered by a growing realization that agricultural change is much more complex than had originally been anticipated, and that high production levels with the new seeds require a costly package that includes, for instance, chemical fertilizers and pesticides that are often unavailable to small farmers.

There are, however, many opportunities for countries to develop native plants into important food crops. Ethiopia, plagued by drought and famine in the 1980s, provides a case in point. The Ethiopians grow a grain called t'ef, which, it is believed, has barely developed from its original wild form. Unlike other staple grains, t'ef needs little rain and grows well in high, cold regions. Its straw makes excellent fodder, and its tiny grains are highly nutritious for humans. Breeding the right varieties of t'ef--that is, working with those seeds which presently grow on marginal land under arid, cold conditions--could result in a grain that might provide basic food needs for Ethiopia as well as for other mountainous African countries.

Ethiopia is one of the rare places in the world where many plant species that now grow in a host of different varieties around the world can still be found in their primitive, uncultivated forms. Some of them offer great potential: there are many hundreds of wild pea varieties, for example. Oil plants such as the castor bean have yet to receive attention from researchers; coffee, whose wild ancestors still flourish in Ethiopia, might become an important export crop for the country, which at present has none.

These, and many other plants that offer great genetic diversity, are collected and sent to gene banks, but their existence on their native soil is threatened by the introduction of new, high-yielding foreign plants developed by plant breeders outside Ethiopia.

Agricultural Education

New information and technology that can help farmers increase their production must be communicated effectively if it is to achieve its purpose. Physical constraints, such as a poor road system, can handicap the spread of information, but various cultural constraints--including verbal or scientific illiteracy among farmers or the